RADIATION SURVEY OF ANOMALY AT NAVY PIER ON AUGUST 2, 3 and 14, 2000

August 21, 2000

BY

LARRY JENSEN

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region 5
Superfund Division
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

Overview

During a radiation survey of the Streeterville area of Chicago on June 20 - 22, 2000, (that included Navy Pier) the U.S. Environmental Protection Agency's (USEPA) radiation Scanner Van encountered an anomaly at the northwest corner of the building. The Scanner Van is equipped with two large sodium iodide gamma-ray detectors. The anomaly was seen as an increase in count rate as the van turned from traveling north to traveling east at the northwest corner of the front entrance of Navy Pier.

USEPA Region 5 Superfund staff investigated this anomaly on August 2 (Larry Jensen, Verneta Simon, Fred Micke) and August 3, (Jensen, Simon) and on August 14, 2000 (Jensen, Simon). Gamma walkover surveys were done on August 2, gamma count rate measurements and portable gamma spectrometer measurements were done on August 3, and gamma exposure rate measurements were done on August 14.

The gamma walkover investigation was a general survey looking for elevated gamma count rates. The meter used was an unshielded 2" x 2" sodium iodide probe with a count rate meter. Later, 10 minute counts at areas of most interest were taken using the same equipment with both an unshielded and with a shielded probe. The latter measurements sought average count rates (by measuring for 10 minutes) in the general area (no shield) and at a specific spot (using the shield).

The portable gamma spectrometer measurements with an unshielded 2" x 2" sodium iodide detector were taken to identify the specific radionuclides at the areas of interest. The gamma exposure rate measurements were taken with a micro-R meter to assess the radiation levels workers and the public might be exposed to.

The areas covered were (1) the slate floor café area on the northwest corner of the building, (2) the adjacent wall, (3) the wall around the corner on the north side of the building and (4) the adjacent sidewalk. Area (1) covered all of the slate floor and the doorways. Area (2) went from the northwest corner of the building, south to the first set of doors. Area (3) went from the northwest corner of the building east to the turn in the wall. Area (4) was the sidewalk adjacent to area (3). (see Figure 1).

Background measurements were taken on the south side of the building at the southwest corner. These measurements included count rates at a nearby picnic table, on the slate floor, on the limestone of the wall facade and on the red brick wall. These measurements were taken to get background levels from the naturally occurring radionuclides.

Gamma spectrometer measurements were taken on a picnic table about 10 feet from the building and on the slate for background comparison purposes as well. This instrument can identify the specific radionuclides emitting in the area of interest.

A gamma exposure rate measurement was made on the picnic table and on the slate floor to establish background levels. This instrument can be used to assess human health impacts.

The areas of highest count rate were found (1) on the slate floor of the outdoor café about 16 feet from the Northwest corner of the building and about 4 feet from the wall and (2) on the green concrete in front of the third set of doors from the northwest corner of the building. For the latter, the highest area was about 1 foot out from the center of the doors. This set of doors was actually four doors.

Gamma Count Rate Measurement Data

In all cases, 10 minute counts were taken with the 2" x 2" sodium iodide detector at the picnic table and on contact with the red brick, limestone, slate and green concrete. Measurements were taken with an unshielded detector (to get an area average) and with a shielded detector to get a focused measurement at the point of interest. Results are summarized in the following table.

Table 1: Gamma Count Rate Data

NAVY PIER SURVEY, AUGUST 3, 2000 GAMMA COUNT RATES (COUNTS PER 10 MINUTES)		
South Background Area		
	Without Shield	**With Shield**
Red Brick Wall	139,760	44,625
Limestone Wall	76,290	15,970
Slate Floor	111,735	32,262
In Front of Four Doors		
	161,850	51641
On North Slate		
	123,537	37,621

Discussion of Gamma Count Rates

Foremostly, there is no indication of substantial anomalies when comparison is made to background levels. The highest deviations from background are about twice. The levels that indicated an anomaly to the Scanner Van are subtle. This, however, is commonly the case with environmental radiation measurements which generally begin to give clues to larger problems at small deviations from background.

The highest count rate measurement is in front of the four doors. This could be due to materials in the concrete or to material under the concrete. The measurements taken cannot resolve this issue.

The next highest count rate is for the red brick wall, for which there is no reason to assume contamination. This count rate appears to be due to natural radioactive constituents.

There is a difference in the measurements on the slate between the south background area and the north anomalous area. This could indicate some radioactive material under the slate, but a slightly higher natural radioactivity composition in the slate cannot be ruled out.

Gamma Spectrometric Data

In all cases, 30 minute counts were taken with the 2" x 2" sodium iodide detector in contact with the area of interest. These produced gamma energy spectra for four areas; the ambient environment in the south background area, the slate in the south background area, the area in front of the four doors and the slate at the northwest corner of the pier building. These spectra are shown in comparison (Figure 2) and individually (Figures 3, 4, 5, 6) below. Peaks in the spectra, when matched to gamma energies, can be used to identify the emitting radionuclide. Peak areas have been bolded on the figures.

It should be noted that, in Figure 2, the software protocol made each spectra the same height when in actuality they were not. A higher spectra means more radioactive emissions. The heights of each spectra were

- Background: 2224 counts per 30 minutes
- Background slate: 6806 counts per 30 minutes
- Four Doors: 9338 counts per 30 minutes
- North slate: 7180 counts per 30 minutes

For each spectra, Regions of Interest were highlighted based upon anticipated gamma energies for radionuclides in the Uranium Decay Series, the Thorium Decay Series and naturally occurring potassium-40. No gamma energy peaks were seen that did not correspond to these anticipate peaks.

Specifically, seven Regions of Interest were set. These are shown in Table 2 below along with the corresponding net counts per 30 minutes. Net counts are the counts after the background counts are subtracted.

The regions selected were

- Thorium Regions of Interest: Region #4 with energies of 911, 968 and 969 kilo-electron volts (keV) for actinium-228 and Region #7 of energy 2614 keV for thallium-208. The count rate for the latter was adjusted to allow for comparability. This was done by dividing the counts per 30 minutes b 0.36 because this gamma is only emitted 36% of the time.

- Uranium Regions of Interest: Region #1 (295 keV) and Region #2 (352 keV) correspond to lead-214. Region #5 (1120 keV) corresponds to bismuth-214.

- A region of mixed uranium and thorium emissions, Region of Interest #3. This is comprised of 583 keV (thallium-208) and 609 keV (bismuth-214).

- Potassium-40 Region of Interest: Region #6 corresponds to 1461 keV.

Table 2: Gamma Spectrometric Data

NAVY PIER SURVEY, AUGUST 3, 2000 GAMMA SPECTROMETER COUNT RATES (COUNTS PER 30 MINUTES)					
Regions of Interest	**Gamma Energy (keV)**	**Background Environment**	**Background on South Slate Floor**	**Four Doors**	**North Slate Floor**
Peak Level for Entire Spectrum					
		2224	6806	9338	7180
Thorium Regions of Interest					
ROI #4	**911, 968, 969**	0	950	530	2089
*** ROI #7 adjusted**	**2614**	353	1633	689	1733
Uranium Regions of Interest					
ROI #1	**295**	408	3151	1244	4371
ROI #2	**352**	727	1216	1358	1389
ROI #5	**1120**	275	800	770	575
Mixed Thorium and Uranium Region of Interest					
ROI #3	**583, 609**	646	2156	1889	2858
Potassium-40 Region of Interest					
ROI #6	**1461**	714	2966	3650	2424
Gamma Count Rate (Counts per 10 minutes)					
Without Shield		----------	111,735	161,850	123,537
With Shield		----------	32,262	51,641	37,621

* Measured count rate divided by 0.36 to adjust for 36% emission rate.

Discussion of Gamma Spectrometric Data

Several observations can be made from the data.

First, all measurements on slate or concrete surfaces are higher than the background environment measurement. The highest levels are about two times background when slate is compared to slate. This indicates that radioactive materials are in or below the slate and concrete.

Second, the peak for spectra are about 40% higher when the background slate is compared to the doorway concrete. This indicates radioactive materials are in or below the slate and concrete.

Third, for thorium and uranium emissions on slate, four of six Regions of Interest (ROI) show clear elevations of count rate and one (ROI #7) shows a small increase. ROI #4 shows a doubling of the thorium count rate and ROI #1 and ROI #2 show a 50% increase in the uranium count rates. The potassium-40 level is lower. This indicates that in or below the slate there are extra uranium and thorium materials compared to background. There is some indication that the thorium levels might be higher than the uranium.

Fourth, for thorium emissions on the concrete between the four doors, the levels are lower than the background slate. The uranium levels are lower in two of three Regions of Interest. For mixed thorium and uranium, the level is lower. It is the potassium-40 level that increases. This indicates a natural radionuclide (potassium-40) may be the source of these elevations. Potassium is a common constituent of many rocks, soils and other materials in the environment.

Gamma Exposure Rate Data

Readings were taken at four of the spots investigated with other instruments. These were (1) a measurement of the general background environment at the picnic table at the southwest end of the pier, (2) a background measurement on contact with the slate at this same end of the pier, (3) a contact measurement on the concrete in front of the four doors, and (4) a contact measurement on the slate at the northwest corner of the pier. The results are tabulated below

Table 3: Gamma Exposure Rate Data

Navy Pier Survey, August 14, 2000 Gamma Exposure Rate (micro-roentgen per hour)			
Background Environment	**Background on South Slate Floor**	**Four Doors**	**North Slate Floor**
5	6	8	5

Discussion of Gamma Exposure Rates

Foremostly, none of these exposure rates would be uncommon for natural background. The fact that the Four Doors level is somewhat higher than the background environment and south slate levels is consistent with its anomalous nature but not indicative of a hazard to workers and members of the general public who might pass through this area occasionally.

If a chest X-ray is taken as a dose of 10 millirem, then the maximum over background level at the four doors (8 - 5 = 3 micro-roentgen per hour) would require 3333 hours of exposure on contact with this spot to get the equivalent dose of one chest X-ray. This is much longer than a full work year (40 hours/week, 50 weeks/year = 2000 hours). The general public will spend much, much less than 3333 hours in this doorway. This is the reason for stating no hazard was present to workers or members of the general public so long as these materials remain in place and intact.

Conclusions

- The USEPA Scanner Van detected a radiation anomaly at the northwest corner of Navy Pier.
- Surface measurements detected two areas of elevated radiation readings in the vicinity of the Scanner Van anomaly, one on the slate floor and one in a doorway. Thus, the Scanner Van anomaly appears to be valid
- The highest deviation from background material levels is slightly more than two times.
- Neither of these anomalies can be construed, in their present condition, a health hazard to either workers or the general public. A hazard could arise if the

overlying surface is removed and there is contaminated soil subsurface that could get on people and lead to skin contact, or the soil could be spread to other areas.

- Field measurements indicate the slate anomaly may be due to thorium and uranium materials. The doorway anomaly may be due to potassium-40.

- It is not possible to determine from the present data if the anomalies are due to natural radioactivity in or below the slate and concrete or if this is due to contaminated material below the slate and concrete.

Because environmental measurements often involve subtle indications for larger problems, it is important to respect even small deviations from natural background until their origin can be established. The same levels may arise from small amounts of near surface and slightly shielded contamination, from large amounts of deeply buried and strongly shielded contamination, and from near surface natural materials. Natural materials and contaminants may be the same radionuclides, namely uranium and thorium.

Recommendations

Because the source of these anomalies cannot be resolved with the present data, it is recommended that

- A section of slate should be removed where background measurements were made. A boring should be made at this point, a downhole gamma log performed and a peak level soil sample taken for analysis of constituents and concentrations. The slate should be analyzed for radionuclide identity and concentration as well.

- A section of slate should be removed where one anomaly was detected. A boring should be made at this point, a downhole gamma log performed and a peak level soil sample taken for analysis of constituents and concentrations. The slate should be analyzed for radionuclide identity and concentration as well.

- At the other anomaly, the concrete area, a section of concrete should be removed. A boring should be made at this point, a downhole gamma log performed and a peak level soil sample taken for analysis of constituents and concentrations. The slate should be analyzed for radionuclide identity and concentration as well.

Instrument Log

Survey Meter, Probe

Ludlum Model 2221 survey meter, S/N 115168
Ludlum Model 44-10 2" x 2" NaI probe, PR101611
Calibrated 2/3/2000, next calibration due 2/3/2001

Portable Gamma Spectrometer

Berkeley Nucleonics Surveillance and Measurement System (SAM) with 3 inch sodium iodide detector, Model 935-2B-AB-Q, S/N 22327, supplied by manufacturer just prior to use, field calibrated at time of use

Micro-R Meter

Ludlum Model 19, S/N 66599
Calibrated 2/2/2000, next calibration 2/2/2001

FIGURE 1: SITE AREA MAP

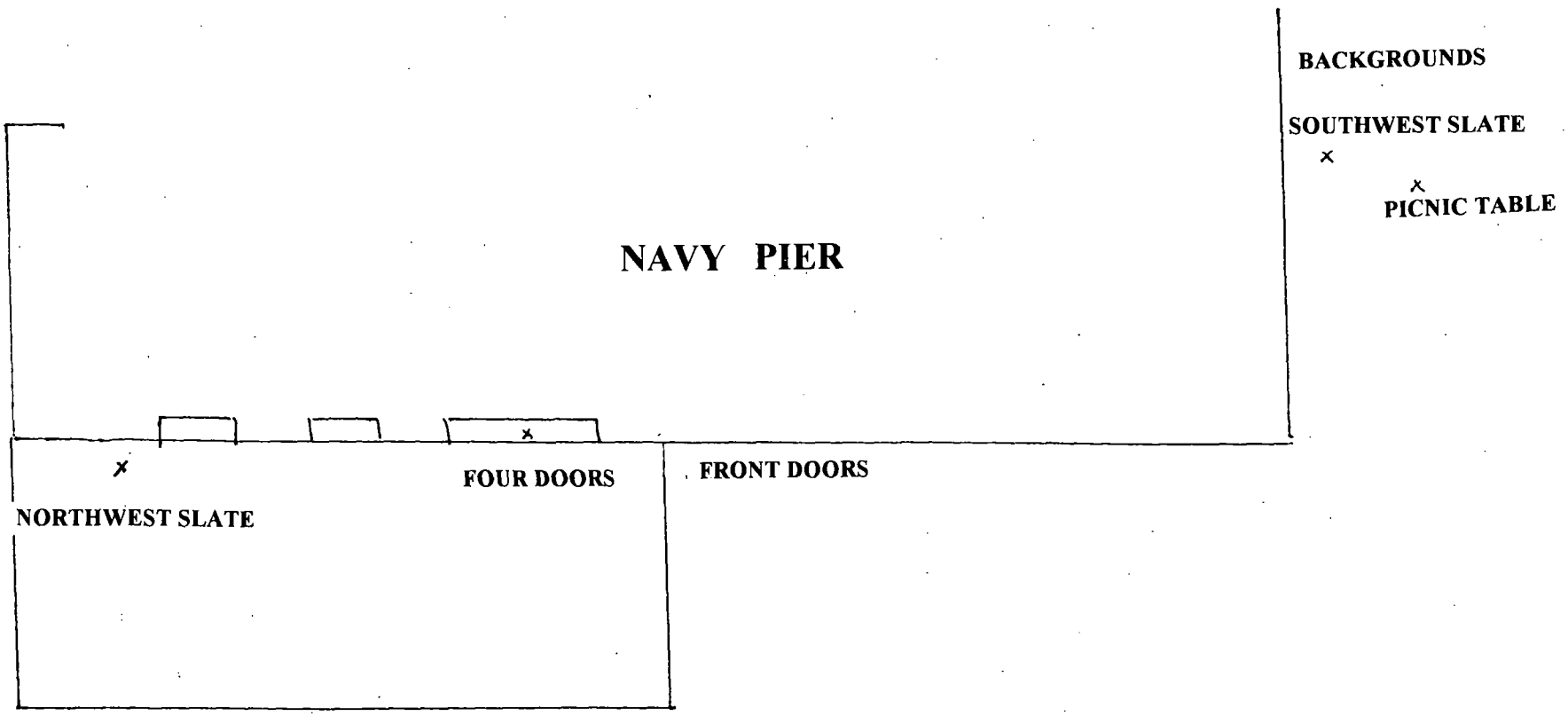


FIGURE 2: COMPARISON OF ALL SPECTRA

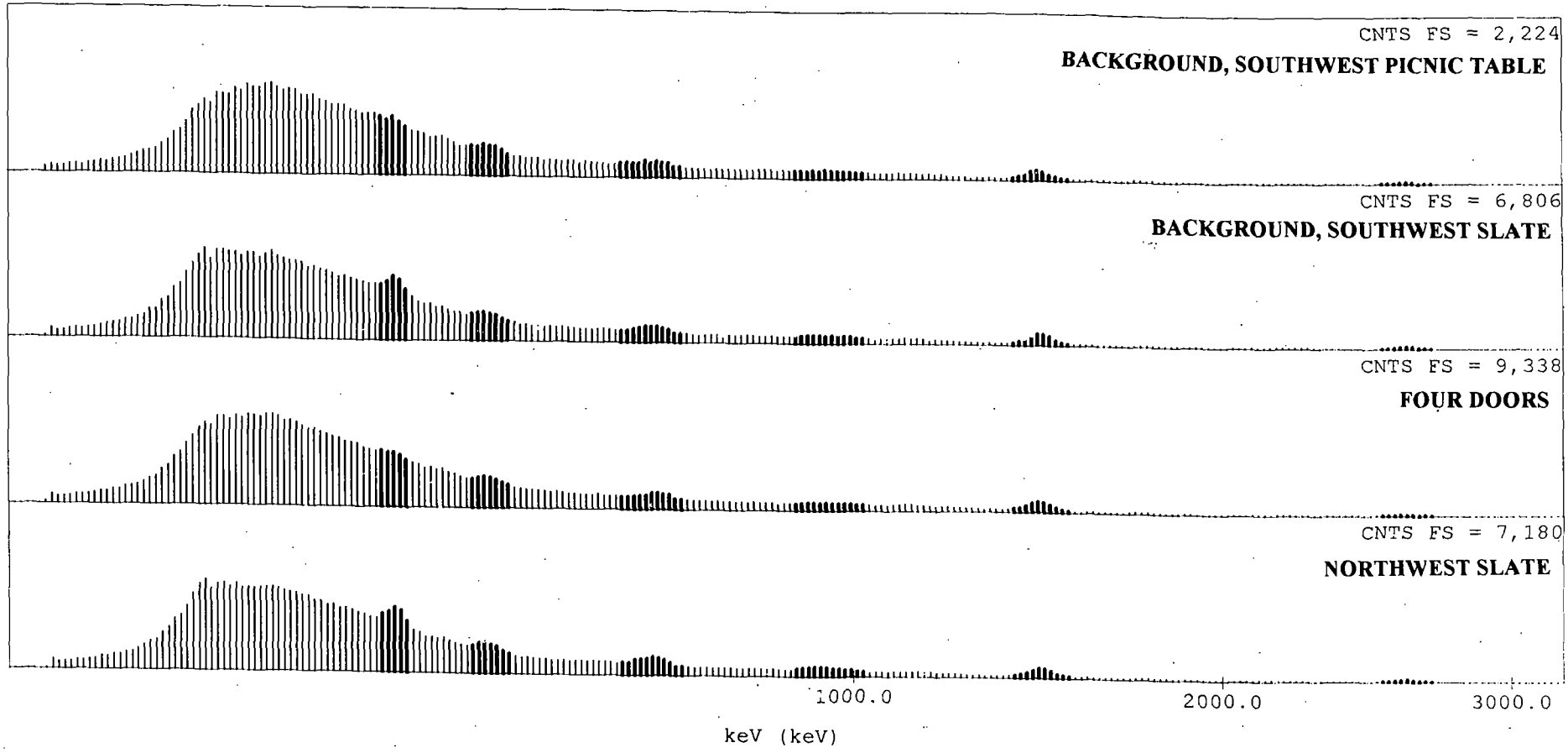
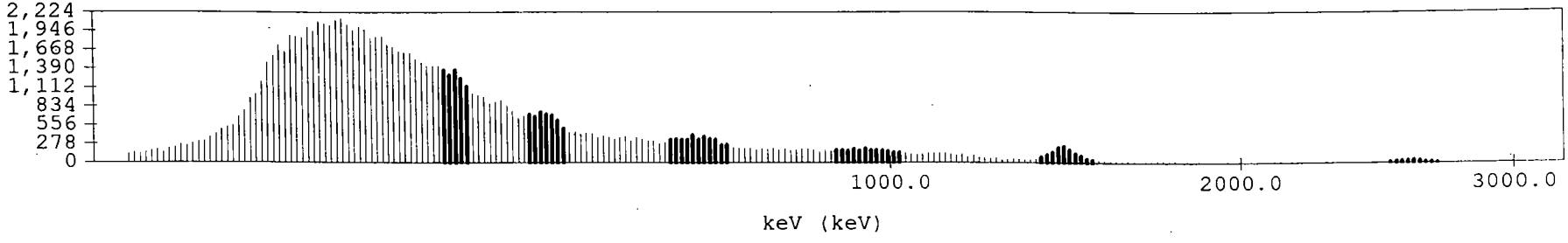
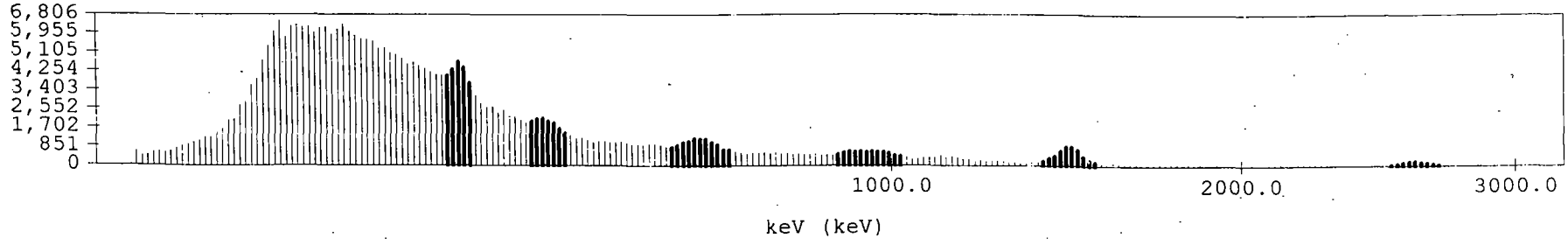


FIGURE 3: BACKGROUND SPECTRUM AT SOUTHWEST PICNIC TABLE



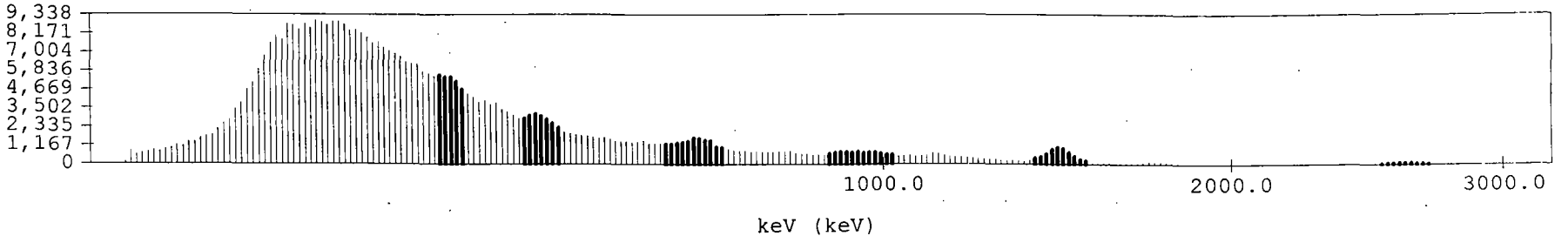
ROI #	ID	ASSOCIATED NUCLIDE	CENTER (keV)	GROSS (cnts)	NET (cnts)	FWHM (keV)	FWHM (%)
1	ROI # 1		230.8	7800 ± 88	408 ± 173	9.88	4.28
2	ROI # 2		341.5	4825 ± 69	727 ± 138	26.81	7.85
3	ROI # 3		598.4	3605 ± 60	646 ± 141	51.96	8.68
4	ROI # 4		941.7	2222 ± 47	0 ± 131	47.18	5.01
5	ROI # 5		1469.0	1244 ± 35	714 ± 62	59.64	4.06
6	ROI # 6		2594.8	149 ± 12	127 ± 16	82.91	3.20

FIGURE 4: BACKGROUND SPECTRUM ON SOUTHWEST SLATE



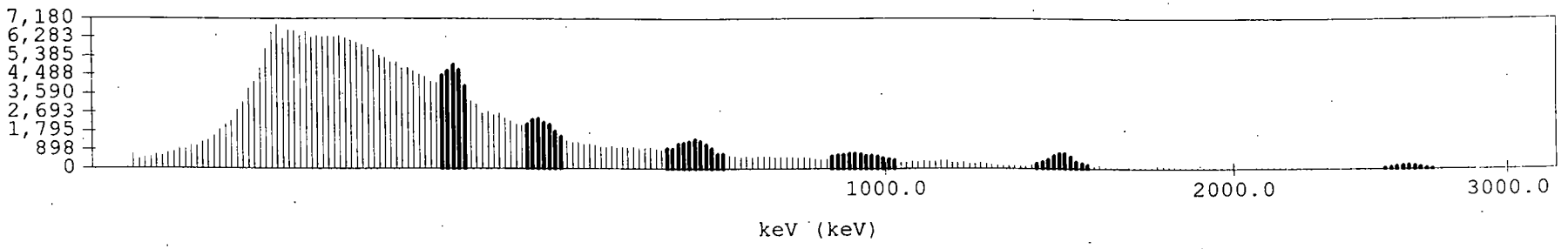
ROI #	ID	ASSOCIATED NUCLIDE	CENTER (keV)	GROSS (cnts)	NET (cnts)	FWHM (keV)	FWHM (%)
1	ROI # 1		236.6	25069 ± 158	3151 ± 301	19.82	8.38
2	ROI # 2		341.5	13497 ± 116	1216 ± 238	31.73	9.29
3	ROI # 3		599.0	10587 ± 103	2156 ± 239	54.10	9.03
4	ROI # 4		951.2	7060 ± 84	950 ± 216	108.34	11.39
5	ROI # 5		1468.9	4571 ± 68	2966 ± 112	67.69	4.61
6	ROI # 6		2594.8	772 ± 28	588 ± 40	83.93	3.23

FIGURE 5: SPECTRUM AT FOUR DOORS



ROI #	ID	ASSOCIATED NUCLIDE	CENTER (keV)	GROSS (cnts)	NET (cnts)	FWHM (keV)	FWHM (%)
1	ROI # 1		233.5	31619 ± 178	1244 ± 350	22.91	9.81
2	ROI # 2		347.0	20030 ± 142	1358 ± 292	29.33	8.45
3	ROI # 3		608.5	14561 ± 121	1889 ± 290	43.55	7.16
4	ROI # 4		940.2	8642 ± 93	530 ± 248	98.22	10.45
5	ROI # 5		1464.9	5780 ± 76	3650 ± 128	71.67	4.89
6	ROI # 6		2617.9	365 ± 19	248 ± 30	80.05	3.06

FIGURE 6: SPECTRUM AT NORTHWEST CORNER SLATE



ROI #	ID	ASSOCIATED NUCLIDE	CENTER (keV)	GROSS (cnts)	NET (cnts)	FWHM (keV)	FWHM (%)
1	ROI # 1		235.5	26673 ± 163	4371 ± 306	21.91	9.30
2	ROI # 2		345.5	14844 ± 122	1989 ± 245	33.53	9.71
3	ROI # 3		598.5	11476 ± 107	2858 ± 243	54.05	9.03
4	ROI # 4		934.4	7393 ± 86	2089 ± 205	92.20	9.87
5	ROI # 5		1465.6	4079 ± 64	2424 ± 111	69.62	4.75
6	ROI # 6		2615.0	768 ± 28	624 ± 38	86.39	3.30